Measuring bulk flows

The need to respond quickly and be flexible to market changes, an increased awareness of environmental protection and ensuring worker safety requires the cement industry to rethink existing practices. The rapid development of sensor technology provides cement producers with a toolbox of solutions that optimise performance potential and strengthen market presence. Non-contact volume flow measurement of conveyed materials can help to optimise the material handling process from quarry to final product.

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The movement and material handling of bulk materials, such as raw materials from the quarry, additives, fuels, or clinker and packaged cement, are tasks carried out mainly by conveyors. In many established cement plants this movement is unsupervised due to physical limitations as well as a lack of labour resources to watch, monitor and adjust material flow. However, the need to lower production costs, improve quality, reduce downtime and enhance tracking accuracy while ensuring environmental protection requires cement plants to keep up with modern sensor technology to provide automated monitoring and process control from quarry to end product.

Industry 4.0 and the cement industry

According to technology and automation leaders, today we are witnessing the Fourth Industrial Revolution, also known as Industry 4.0 – The Age of Autonomous Flexibility. Industry 4.0 leaders use innovative technology to yet again revolutionise production and resource efficiency through the digitisation of process data collected with smart sensors and controls.

The cement industry can learn from Industry 4.0-leading sectors, and adopt best practices and technology where applicable. One of the key components of Industry 4.0 is the ability to take data from process sensors to a centre that can evaluate this information and recommend closed-loop process changes. In addition, data collected from the process sensors can be stored and evaluated over time to spot patterns and determine trends. Attaining this level of 'Big Data' and cloud accessibility in the 'Internet of Things' (IoT) increases the potential for process improvements, as well as opening up many opportunities to quickly assess and respond to consumer trends and environmental correlations.

Figure 1: Bulkscan® sensors

Monitoring flow in the cement plant

Knowing how much raw material is in the yard is a challenge historically met by rough measurements, guesses and assumptions of length, width and height to estimate the amount of material

Figure 2: non-contact volume flow measurement using Bulkscan® sensor and belt speed encoder

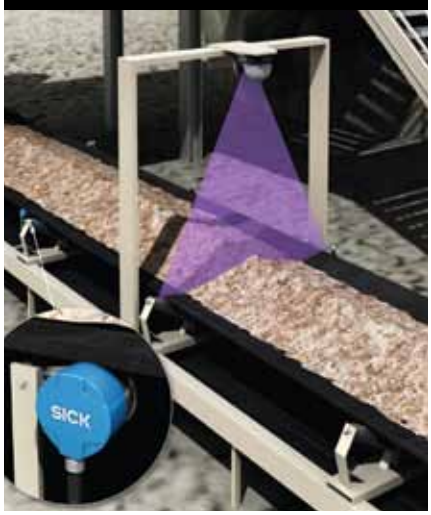


Figure 3: principle of non-contact volume flow measurement on a conveyor belt

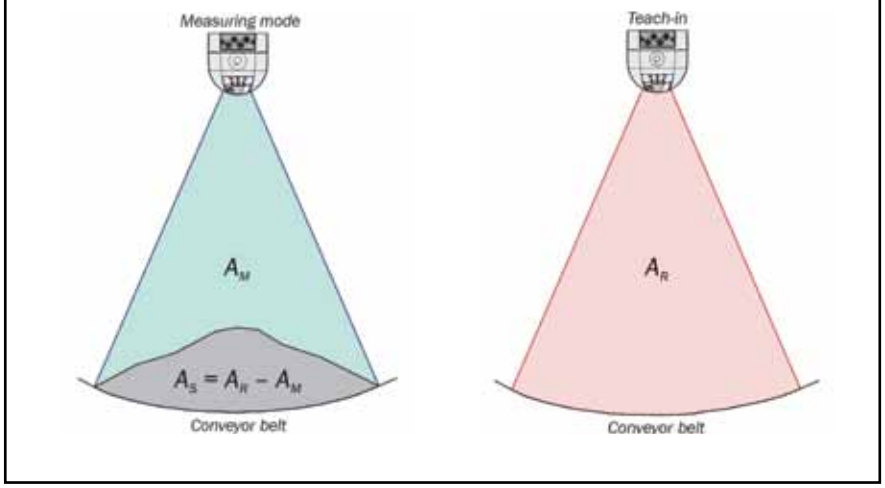


Figure 4: Bulkscan® sensor over inclined pan conveyor for clinker transport (left) and an empty clinker cooler pan conveyor

available. Moreover, it is essential that conveyors provide a non-stop flow of raw materials, additives, fuel, clinker and cement upstream and downstream of the pyroprocess.

To monitor material flow, mechanical belt scales are often used. The scales measure mass, and the volume of material transported is calculated using an average material density.

However, this process only works well when the belt is maintained properly and the material density does not change. Over- or under-tensioned belts generate measurement errors as well as material spillage that is unaccounted for in the process calculations.

Changes in bulk material size and moisture content alter bulk density. Material density is used to convert mass from the weigh scales into volume, as well as to convert volume into mass. When the density is incorrect, so too are the volume and mass calculation. Therefore, any downstream processes that rely on accurate mass, volume and density measurements are less than optimally efficient.

These errors in mass and volume flow rates are not only common but are also viewed as a necessary evil, only overcome by additional investment in frequent maintenance, repair and calibration.

Furthermore, historic methods of determining density require frequent sampling and off-line measurement and calculation. As a result, required adjustments to the downstream process are delayed and optimal efficiency is not achieved. While some methods of in-situ density measurements are possible, such as nuclear-based technology, they come with a high price tag to purchase, operate and maintain.

Working principle and application

To mitigate or eliminate such issues quickly, easily and cost effectively, cement plants can employ recently-launched Bulkscan® flow measurement technology, enabling the yard manager to directly measure the contour, volume, height and material distribution through the use of LiDAR (light detection and ranging)-based technology (see Figure 1). These sensors can be mounted onto cranes and reclaimers as well as over conveyor belts.

Inside the Bulkscan sensor, high-pulse laser beams create a profile of the material on the conveyor, which, in combination with belt speed, represents volume flow and calculated mass flow (see Figure 2).

The measurement principle is based on a laser beam that is deflected internally across a rotating mirror. The sequential order

Figure 5: material height measurement on a conveyor belt

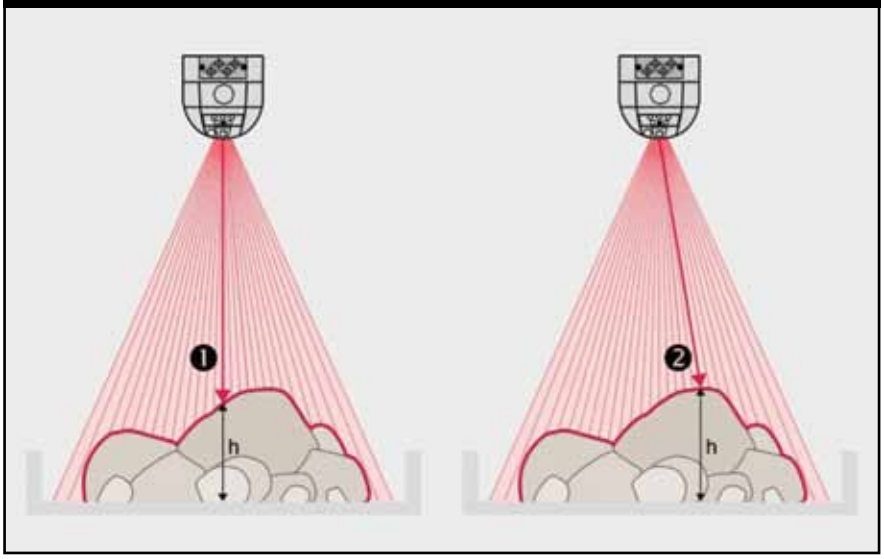


Figure 7: bulk edge and conveyor edge monitoring

of the laser pulses is synchronised with the rotation frequency of the motor and the desired angular resolution. Generally, the motor rotation speed is determined by the maximum emitted pulse frequency of the laser source and the desired angular resolution. The laser beams scan the surface area of the material on the conveyor and forward this information to the measurement device, which compares this data with an empty reference conveyor belt (see Figure 3).

Application and benefits

Use as a stand-alone device

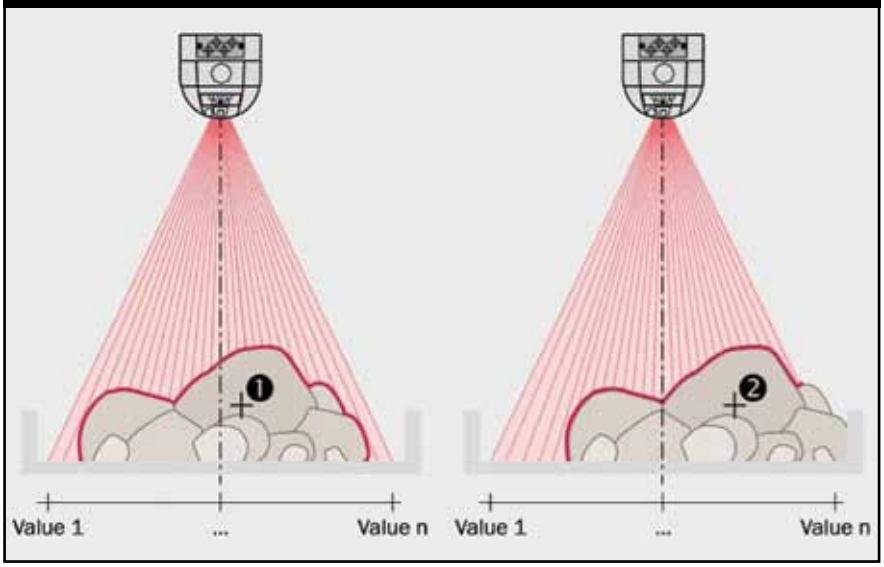
By using Bulkscan, plant operators directly measure volume flow on conveyor belts, bucket elevators or drag chain conveyors. This technology works both outdoors in harsh conditions at the mine or quarry, as well as inside the cement plant. Bulkscan mounts out of the way above the conveyor and measures volume flow without any material contact, making it virtually maintenance free (see Figure 4).

The collected data can either inform manual processes, or act as an input to fully-automated systems to drive changes in material flow and composition.

Furthermore, Bulkscan can detect large objects on the belt and trigger an automated process to stop the conveyor in a timely manner, while simultaneously alerting the plant operator before equipment in the downstream process is damaged by oversized bulk material (see Figure 5).

Bulkscan also helps plant operators to optimise conveyor operation and reduce unplanned downtime. The same laser beams used to measure the bulk flow rate also provide information about the exact height and distribution of the bulk material on the conveyor. In addition, the centre of gravity of the load and the distance between the bulk material and the conveyor edge is measured and provided to a closed-loop system to adjust material distribution on the belt. This process automation helps increase belt life and decrease one-sided roller wear and downtime (see Figures 6 and 7).

Figure 6: centre of gravity measurement on a conveyor belt



Use with weigh scales

When Bulkscan is used in conjunction with a weigh scale, the actual bulk density can be determined in real time with a significantly lower cost of ownership. The device directly measures the volume while the weigh scale directly measures mass. When these values are known, density can be calculated. Access to real-time in-situ density measurement through the addition of Bulkscan can be achieved at a very low cost and provides a low-maintenance solution to acquire valuable density information.

Conclusion

Large numbers of installations worldwide have shown the benefits of state-of-the-art sensor solutions for the cement industry. Monitoring and optimising the logistics of moving both bulk material and final product are by far the most important applications in which Bulkscan can increase a plant's output. These devices enhance value by collecting and delivering production data for analysis and optimisation of material flow, ultimately leading to higher throughput and increased capital efficiency. ■